CITY DATA STRUCTURES

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Outline

- Motivation
- The visualization problem
- The network problem
- The database problem
- Conclusion
- Examples
- Discussion

Motivation

- **superior goals**
  - city geographical information system development (3D city GIS)
  - detailed modeling of the whole city
  - emphasis on semantics-topology-geometry
- **discovered issues**
  - the visualization problem
  - the network problem
  - the database problem

The visualization problem

- **fast and efficient rendering**
  - algorithms, scene graphs, ray-tracing, …
  - visibility, backface culling, proximity, …
  - LODs, impostors, …
- **photorealistic sense**
  - precision of models
  - textures, materials
  - interactivity


Jaime Vives Piqueres


80
50


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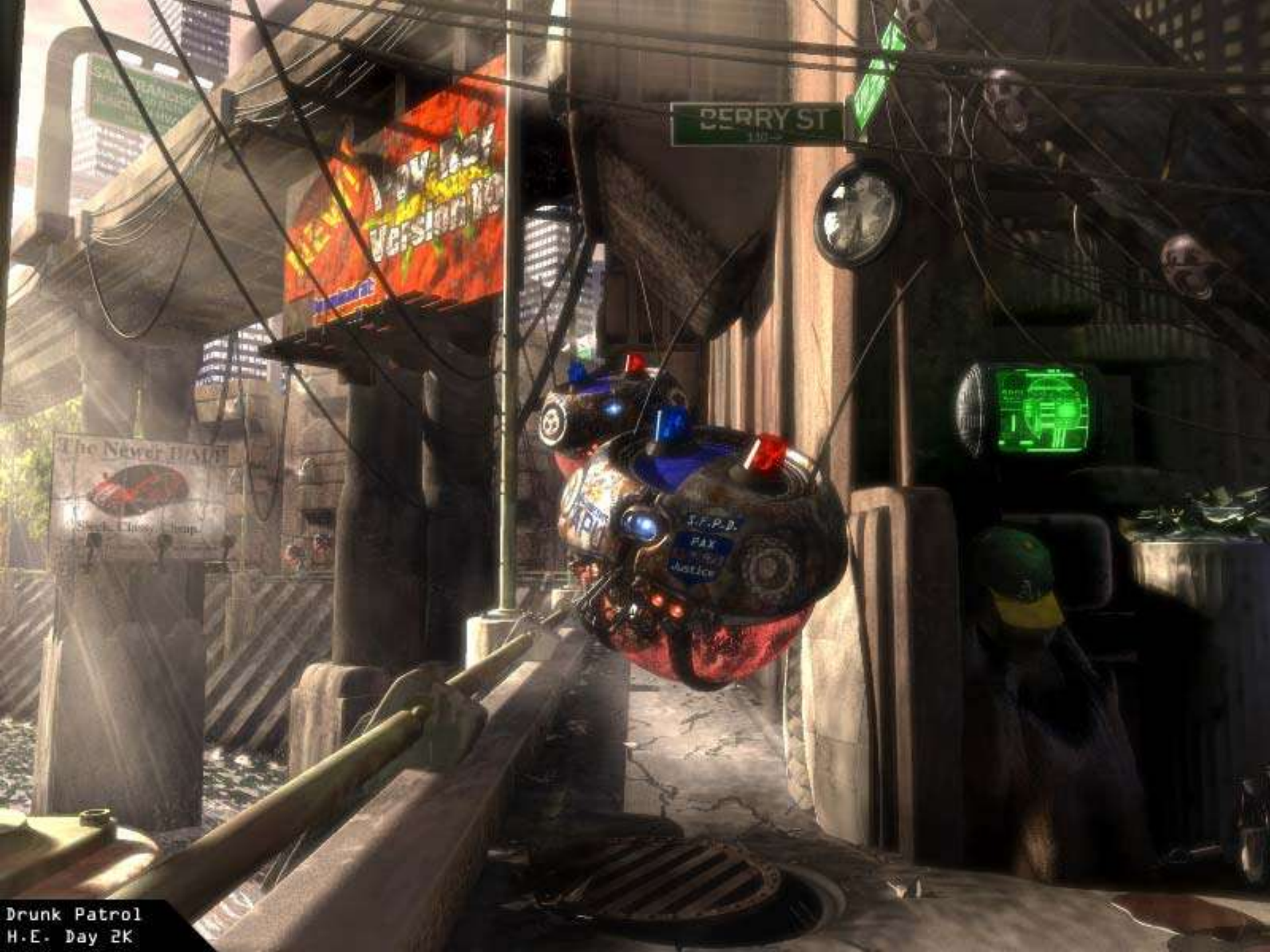
TOW
AWAY
ZONE
Copyright 2000 Gilles Tran

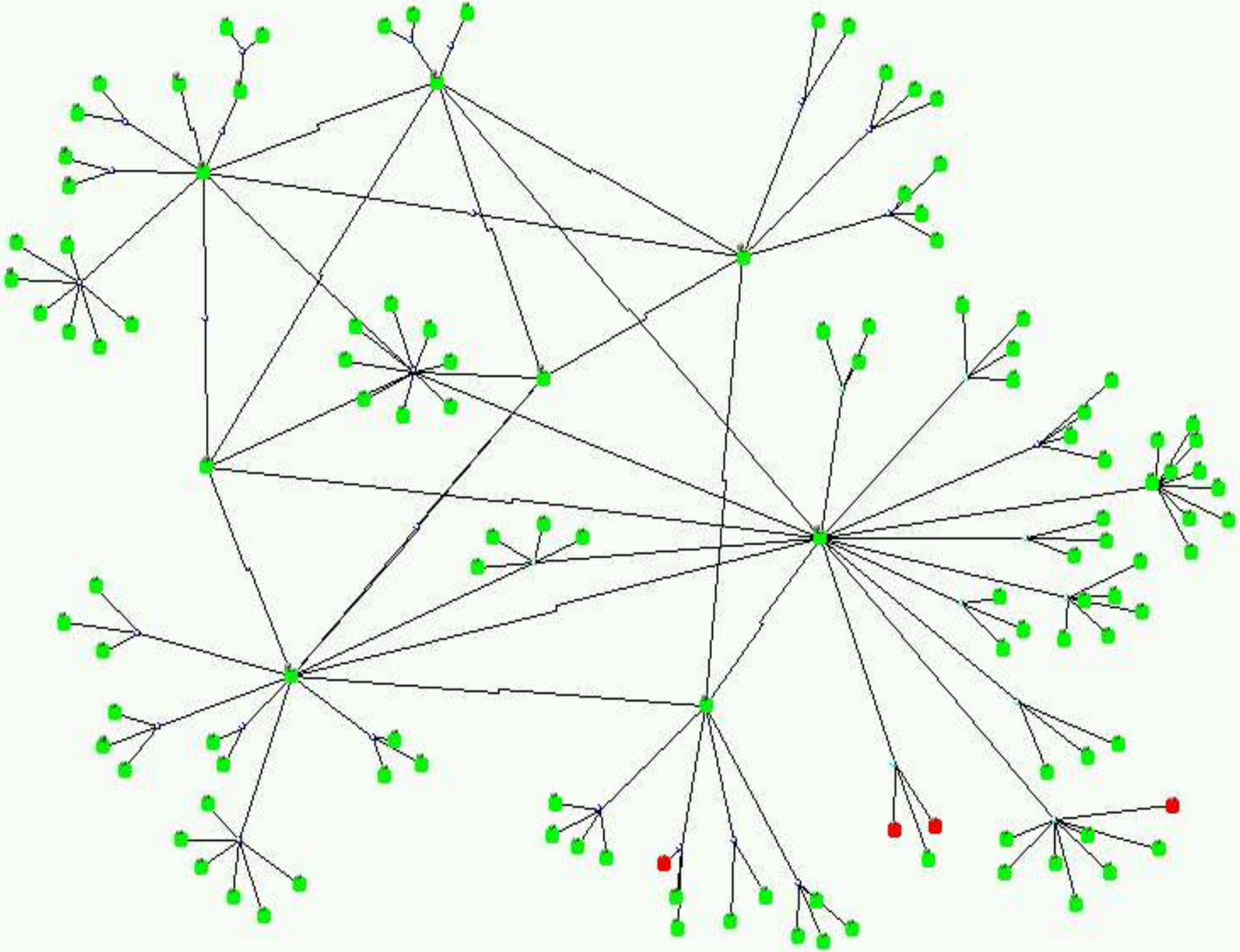


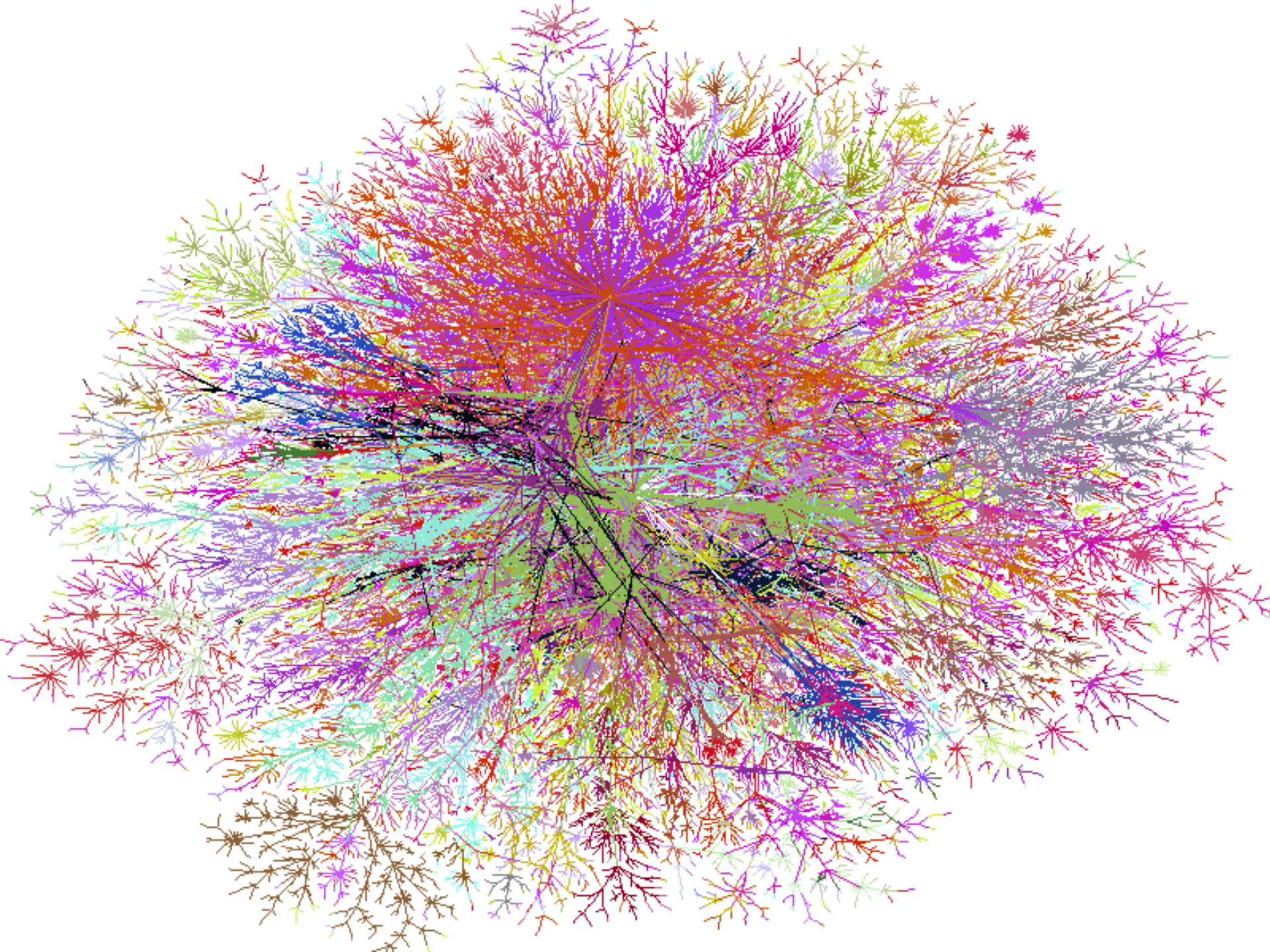
Drunk Patrol
H.E. Day 2K

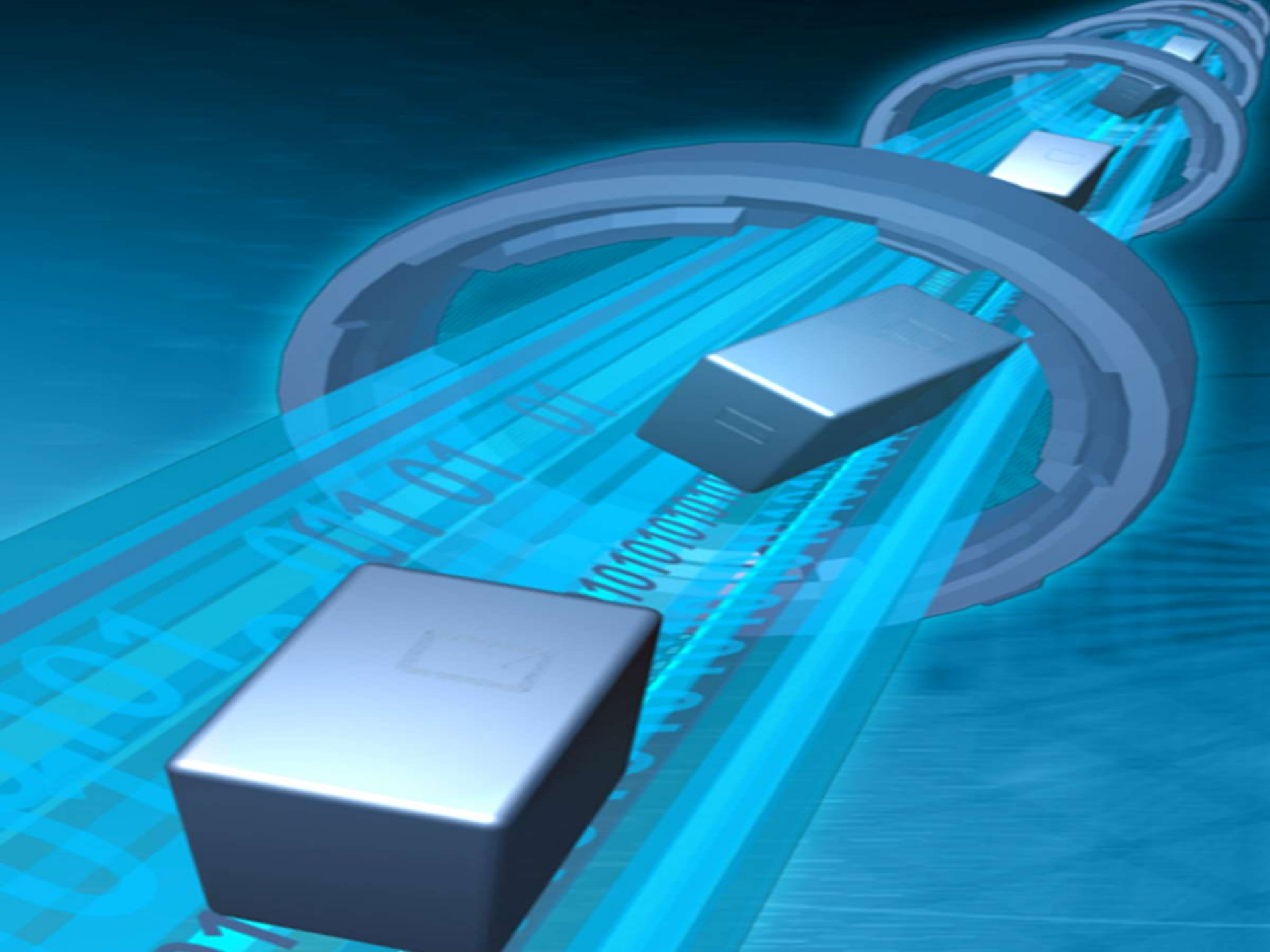
The network problem

- **network capacity**
  - how many connections at a time?
- **network speed**
  - how much data transportable in the time?
- **network reliability**
  - how many times we need to transfer data?

  - **LAN, WAN, VPN, TCP-IP, UDP, ...**





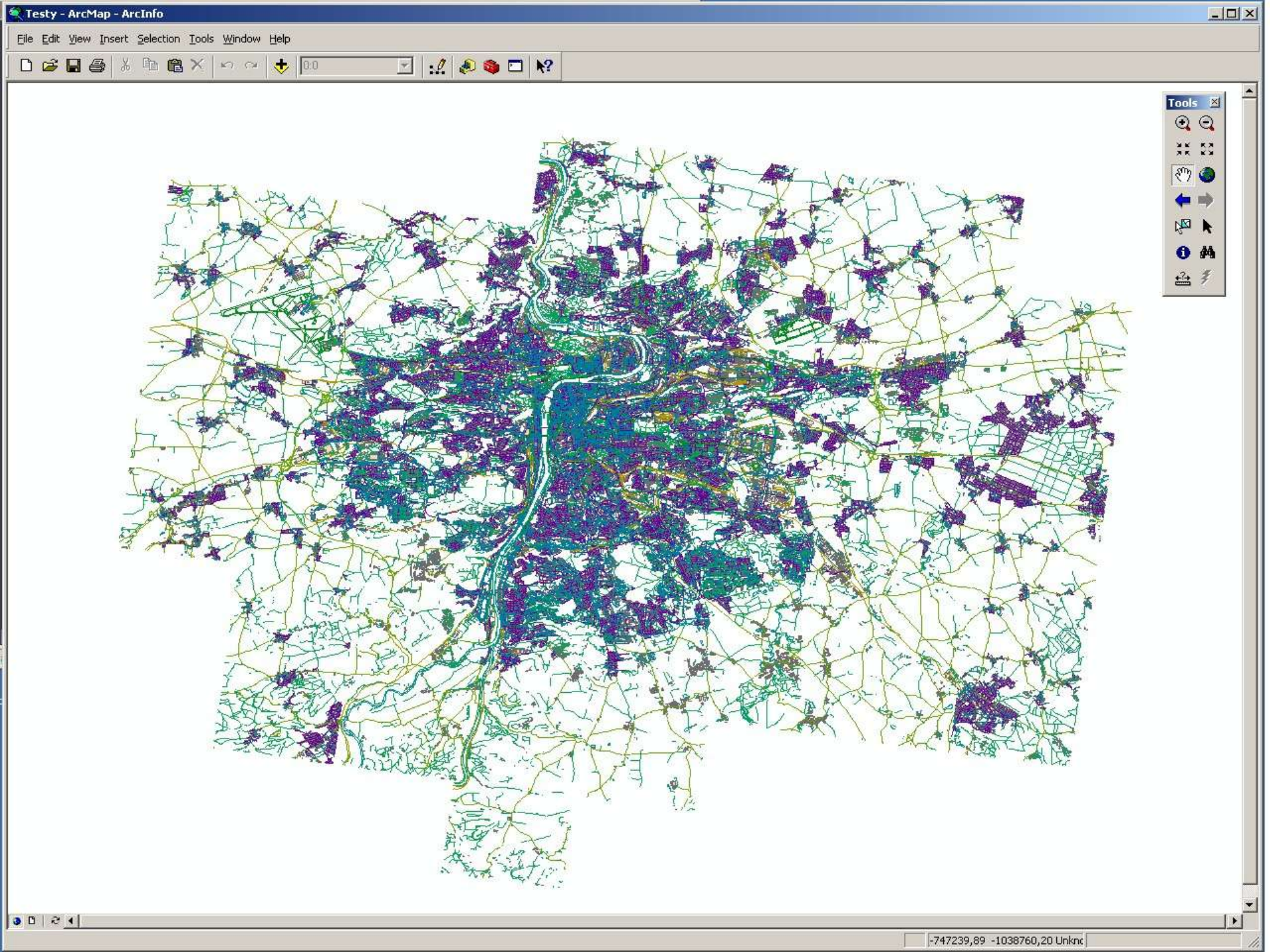


The database problem

- **geometry data**
  - CSG geometry, meshes, vertexes, splines
  - textures, materials, colors
- **semantics data**
  - information systems, records, cadastre
- **topology data**
  - next to, above, below, left, right, part of, consisting of, connected with, adjacent

GIS

- **geometry (mostly 2D)**
  - points, lines, polygons
  - DEM, DTM, TIN
- **semantics**
  - attribute data, .DBF files
- **topology**
  - spatial querries, table joins
  - spatial analyses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Tools
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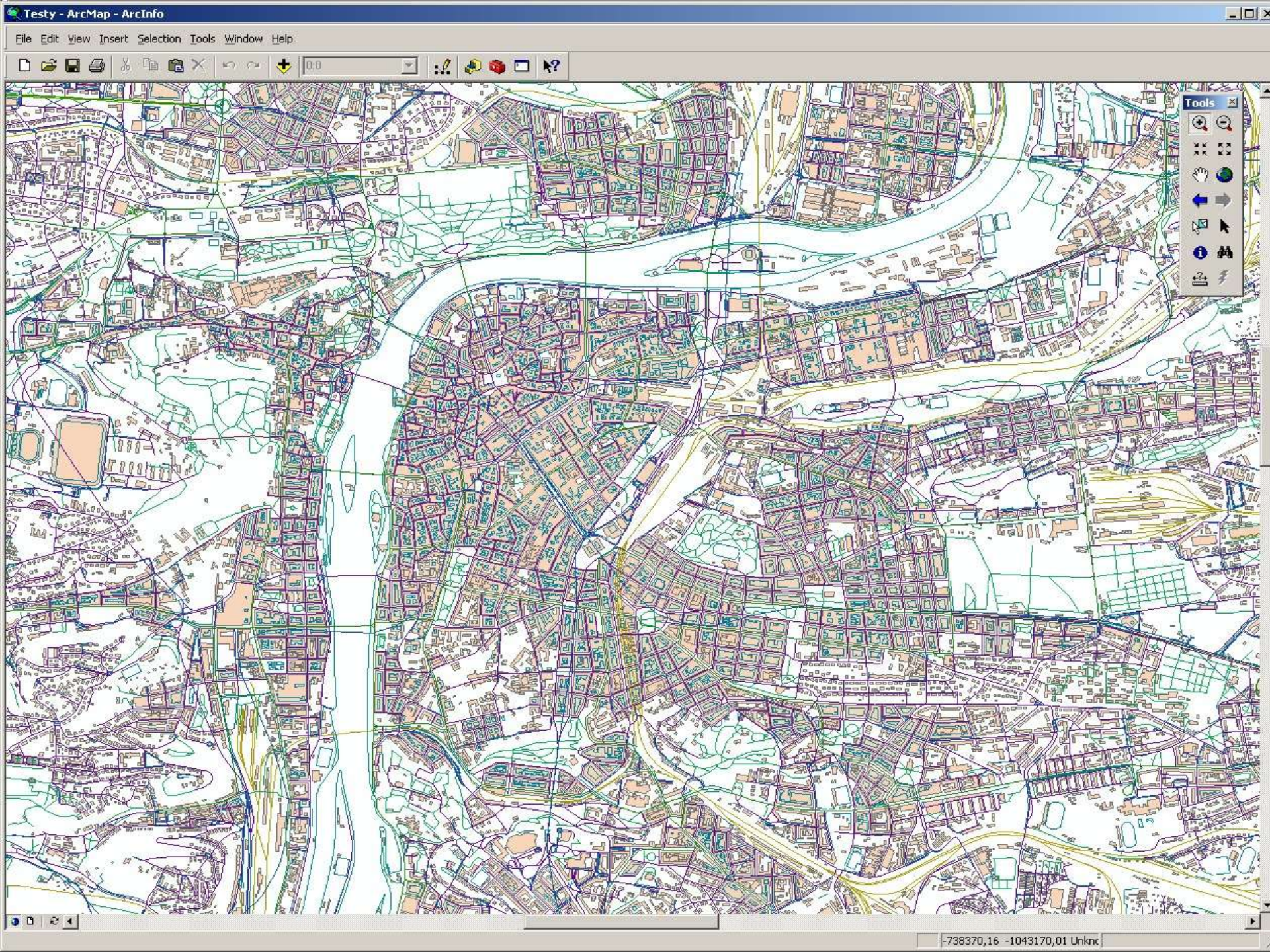
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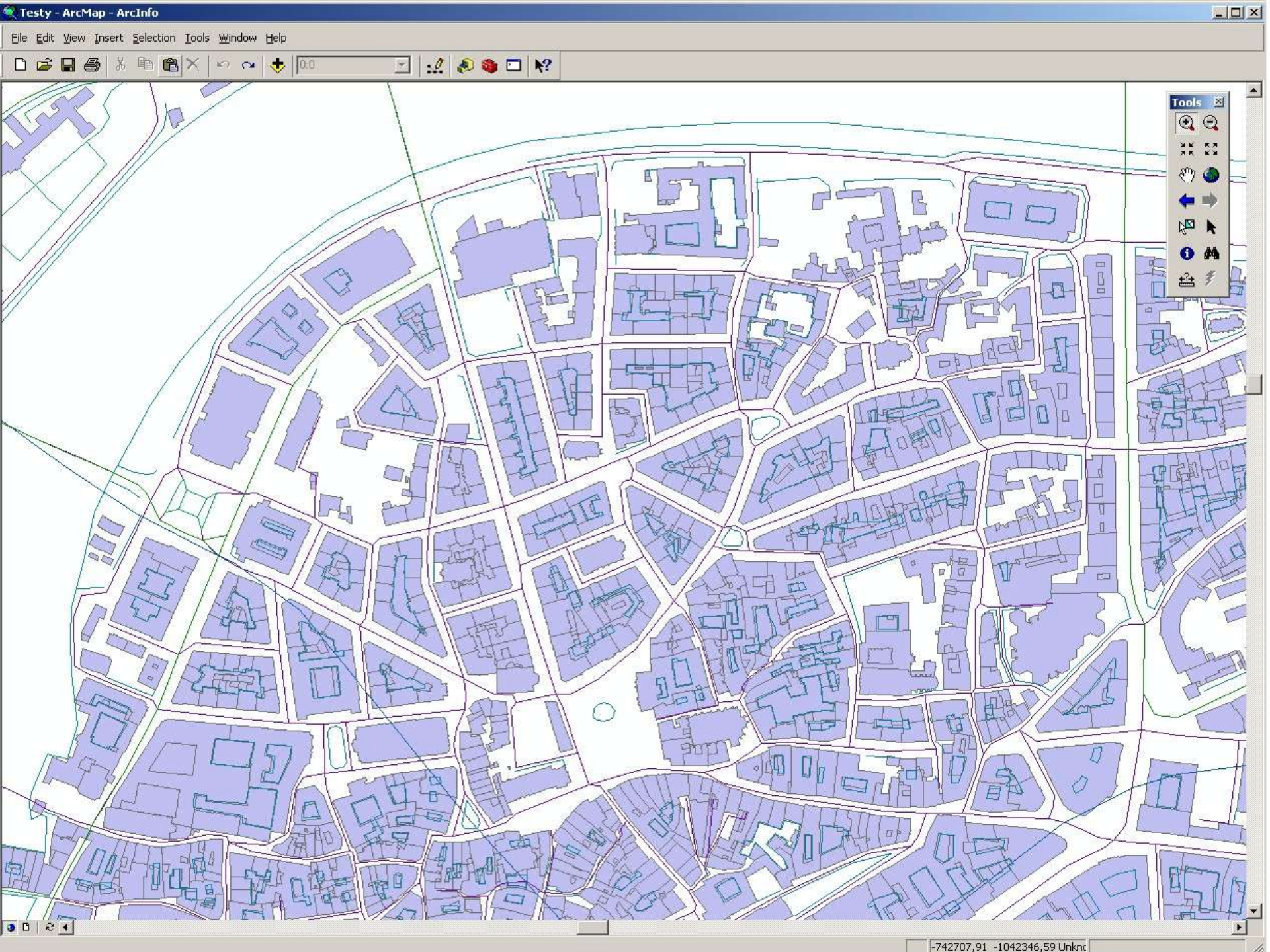
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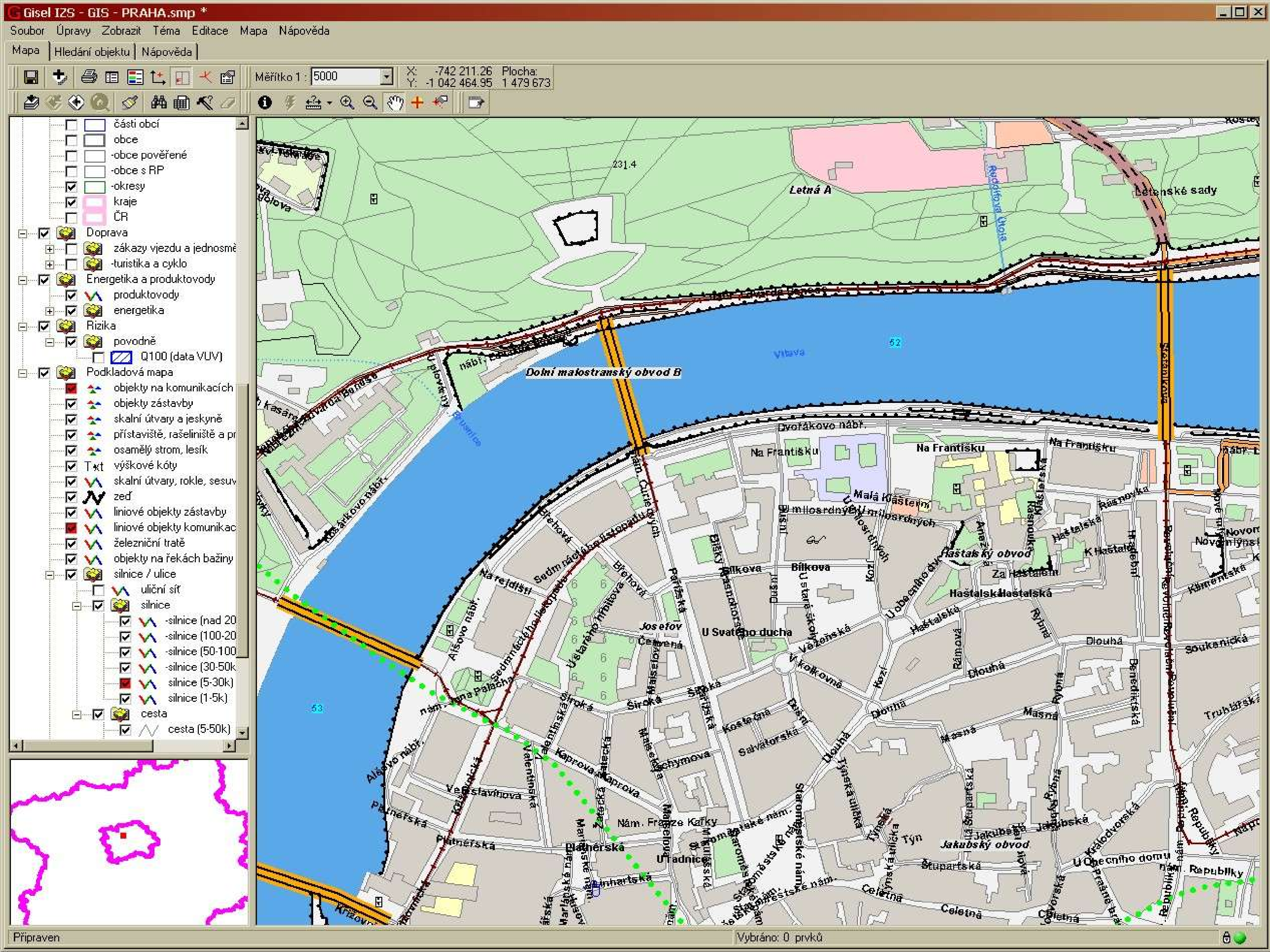

Gisel IZS - GIS - PRAHA.smp *
Soubor Úpravy Zobrazit Téma Editace Mapa Nápověda
Mapa
Hledání objektu
Nápověda
Měřítko 1 : 5000
X: -742 211.26
Y: -1 042 464.95
Plocha: 1 479 673
části obcí
obce
-obce pověřené
-obce s RP
-okresy
kraje
ČR
Doprava
zákazy vjezdu a jednosmě
-turistika a cyklo
Energetika a produktovody
produktovody
energetika
Rizika
povodně
Q100 (data VUV)
Podkladová mapa
objekty na komunikacích
objekty zástavby
skalní útvary a jeskyně
přístaviště, rašeliniště a pr
osamělý strom, lesík
výškové kóty
skalní útvary, rokle, sesuv
zeď
liniové objekty zástavby
liniové objekty komunikac
železniční tratě
objekty na řekách bažiny
silnice / ulice
uliční síť
silnice
-silnice (nad 20
-silnice (100-20
-silnice (50-100
-silnice (30-50k
silnice (5-30k)
silnice (1-5k)
cesta
cesta (5-50k)
Letná A
Letenské sady
231.4
Vltava
52
53
Dolní malostranský obvod B
Dvořákovo nábř.
Na Františku
Malá Klášterní
Haštalský obvod
Josefov
U Svatého ducha
Bílkova
Haštalská
Dlouhá
Kozí
Široká
Pařížská
Kaprova
Veleslavínova
Platnéřská
Nám. Franze Kafky
U radnice
Týn
Jakubský obvod
Jakubská
Štupartská
Celetná
U Obecního domu
Republiky
Revoluční
Truhlářská
Soukenická
Rybná
Benediktská
Masná
Vězeňská
Kostečná
Salvátorská
Žatecká
Maiselova
Alšovo nábř.
Na rejdišti
Břehová
Elišky Krásnohorské
Kolkovna
Rámová
Dušní
Staroměstské nám.
Týnská ulička
Kamenická
Hradební
K Haštalu
Za Haštalem
Anežská
Řásnovka
Připraven
Vybráno: 0 prvků

3D GIS

- The big area of research
- Few extensions to old 2D GIS
- Many drawbacks of former technologies
- Main problems
  - lack of quality data structures
  - usage of file systems and RDBMS
  - nonefficient exploitation of contemporary visualisation possibilities

3D Geometry data formats

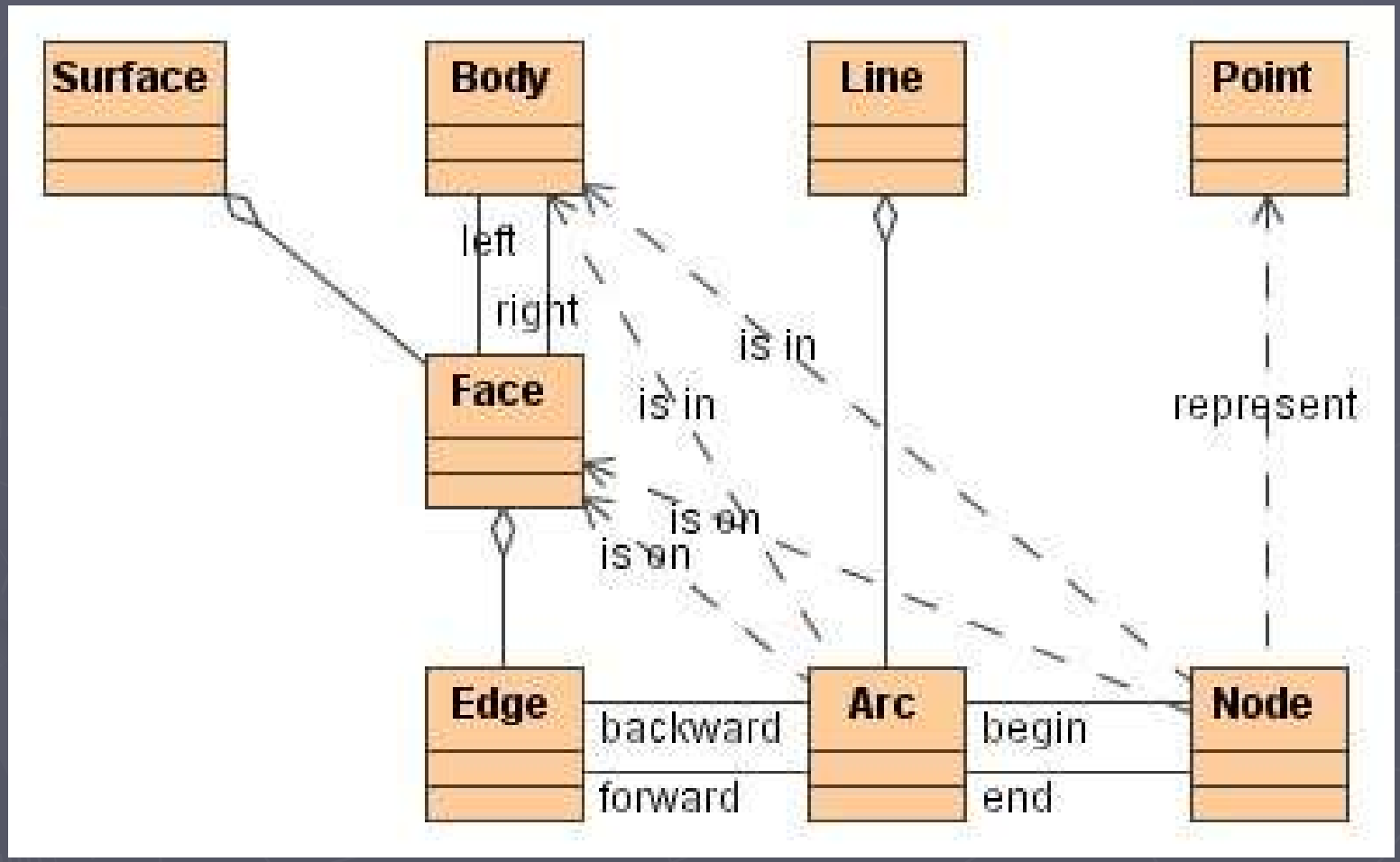
3D2	EGDR	MI	Poly	SAT	V
3DML	FACT	MOL2	PS	SCENE	VEF
AC3D	FFIVW	MovieBYU	POVRAY (v3.6)	SCN	Vision3D
3DS	fld	MS3D	Macperspective	SDML	VLA
ASE	FLT	MSLD	PowerFlip	Old SDML	vmd
ASC	GEO	NDO	PRT	SHP	vol
ALC	Geom	nff	PRT	SLC	VRI
AL2	GLF	enff	q3o	STL	WLD
BMF	HIV	NUAGES	QuickDraw3D	STP	WRL
CDF	HPGL	OBJ	radio	STEP	WRM
CGM	hf	OFF	RAD V3.1	Super3D	VRML V2.0
cinema4d	IGES	OFF	RAD V2.5	SURF	VRML V1.0
COB	ILDA	OpenGL	ArchiCAD	Tachyon	VRML 97
cube	Infini3D	OOGL	StrataStudio	FORM TDDD	WMF
DF3	Inventor	PEDR	RAW	tet	XYZ
Direct-X	IRIT	PDB (V2.1)	RAY	TIN	YASRT
DMO	LWOB	PHD	RAY summary	TM	YAODL
DWF	Lightwave 5.x	PI	RIB	TP	
DXF2000	MDL	PLG, FIG, WLD	Rotater	TRI	
Minimal 3D DXF	MGF	PLY	rsd	UNREAL	

3D GIS data model

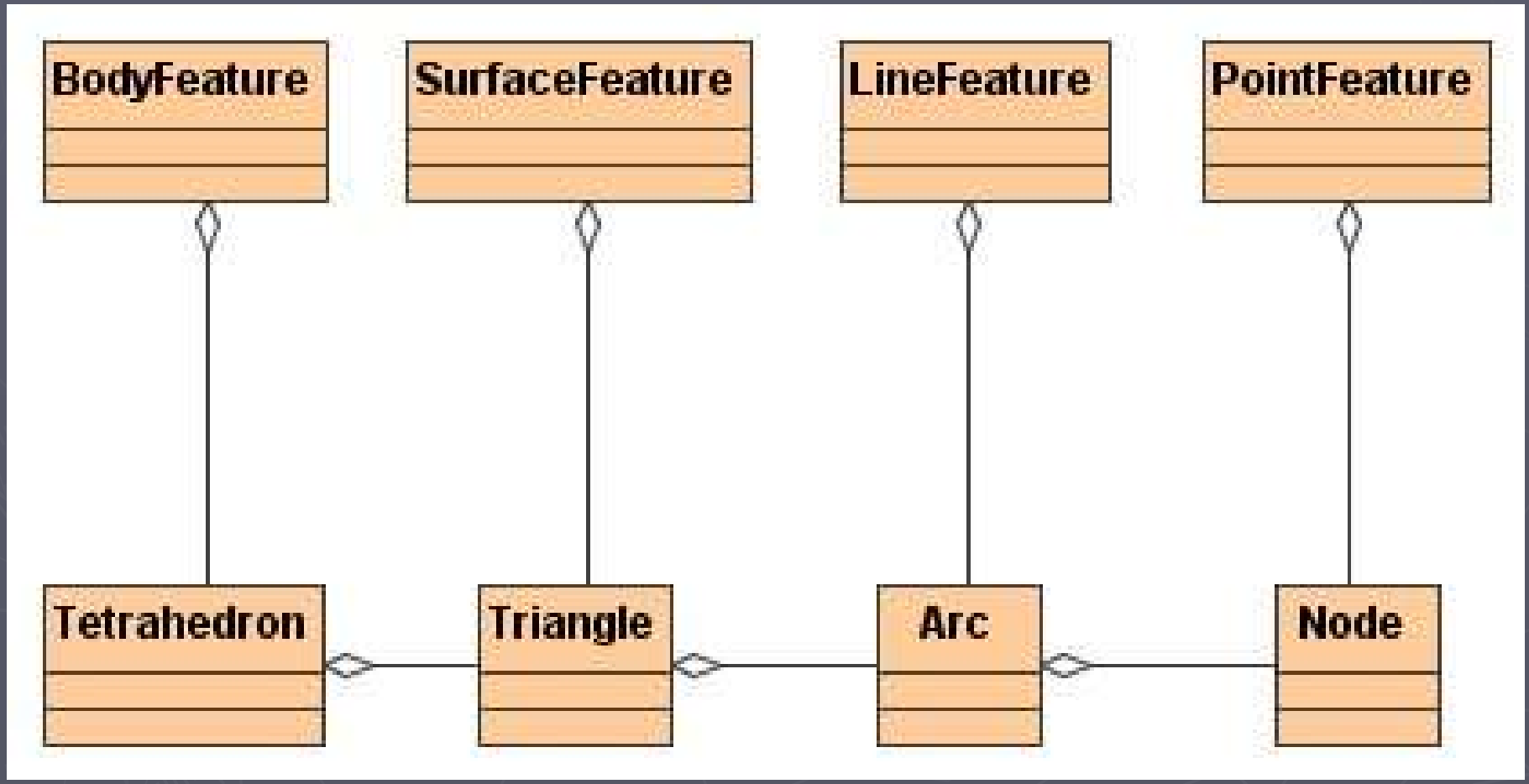
- Examples of 3D data models
  - FDS – Molenaar
  - TEN - Pilouk
  - UDM – Coors
  - SSS – Zlatanova
  - OO3D - Shi et al.
  - GeoToolKit - Balovnev et al.
    - includes visualization problems (boundingBox)

quite similar – deal with basic geometry

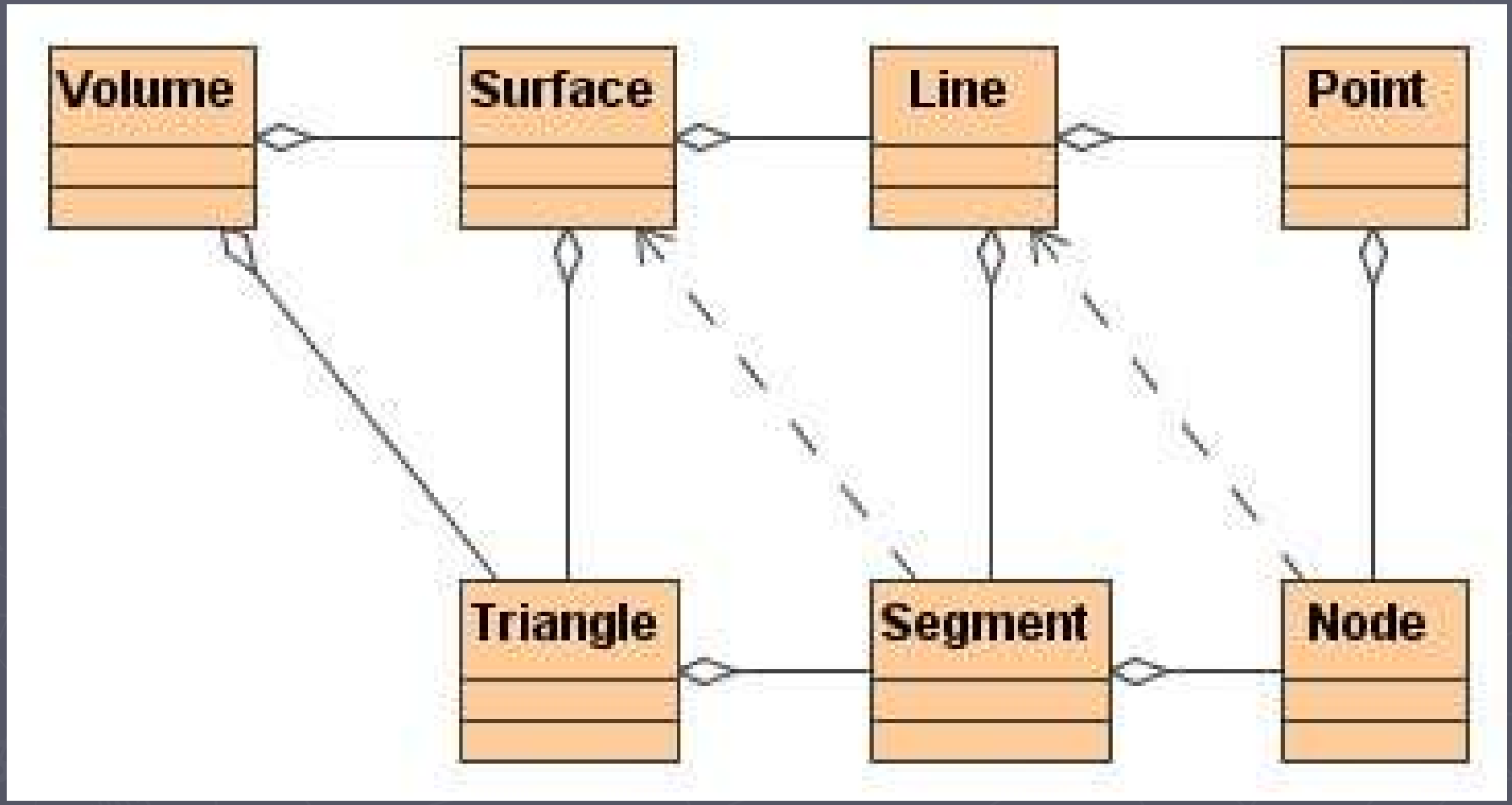
FDS - Molenaar



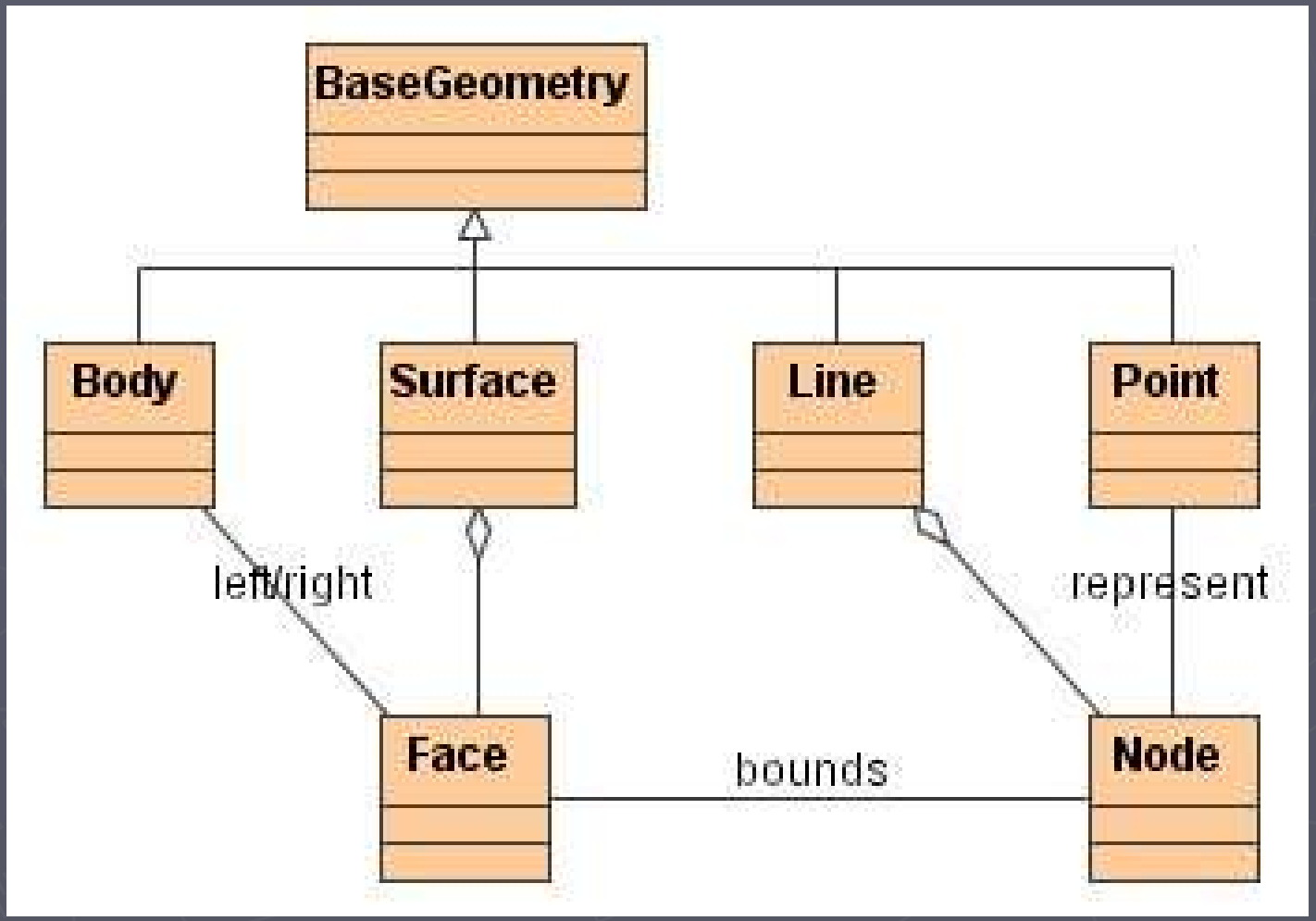
TEN -Pilouk


BodyFeature
SurfaceFeature
LineFeature
PointFeature
Tetrahedron
Triangle
Arc
Node

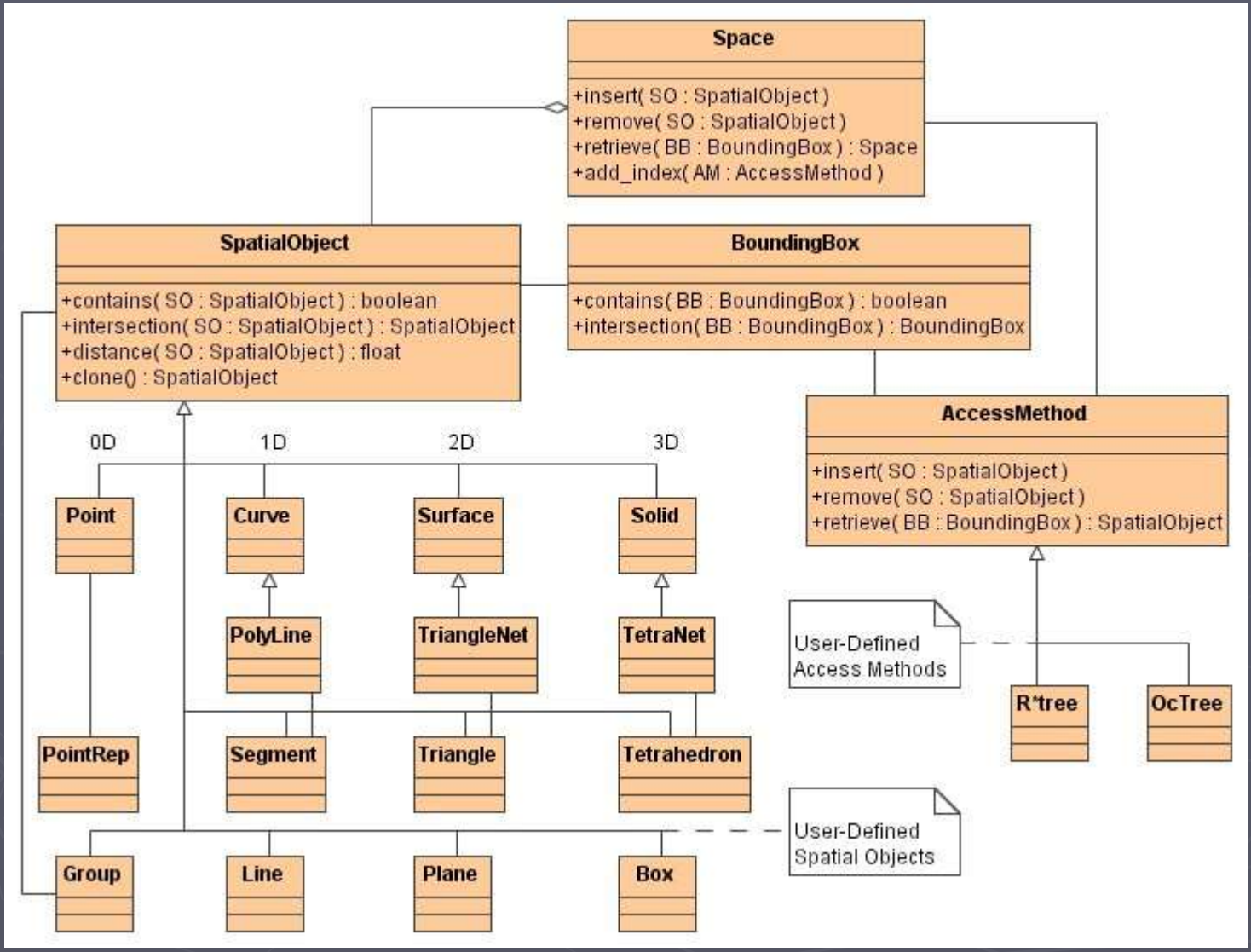
OO3D – Shi et al.



UDM, SSS – Coors, Zlatanova

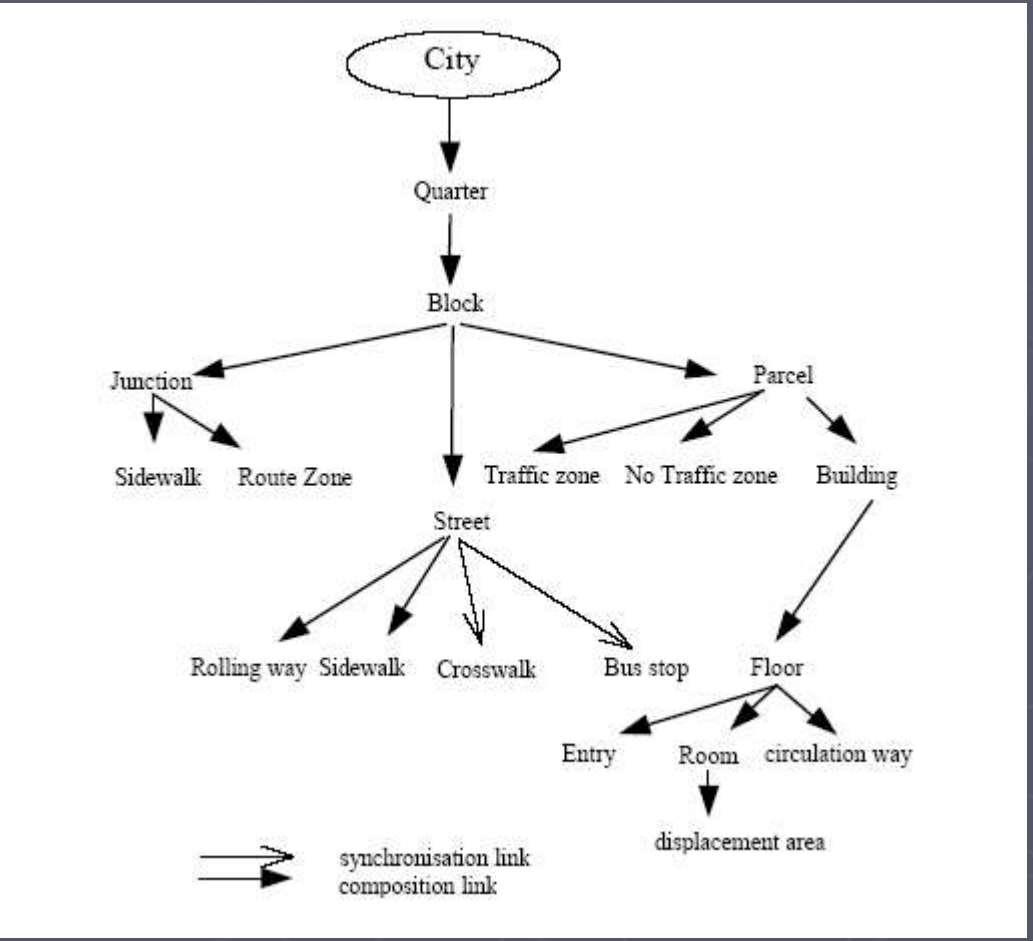


GeoToolKit - Balovnev et al.



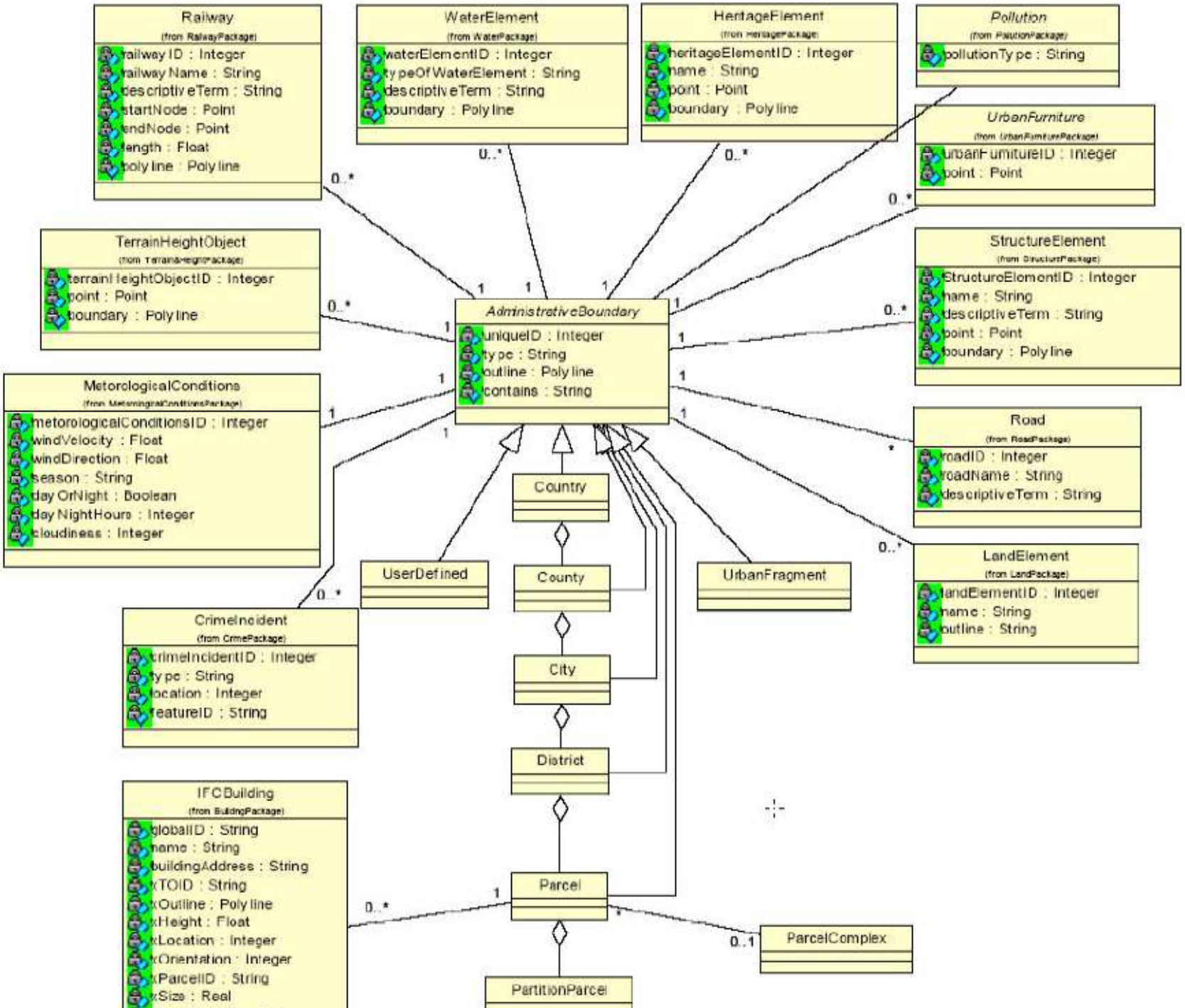
Farenc, Thalmann et al.

- City hierarchical decomposition
- Deals with logical relationships amog parts of the city

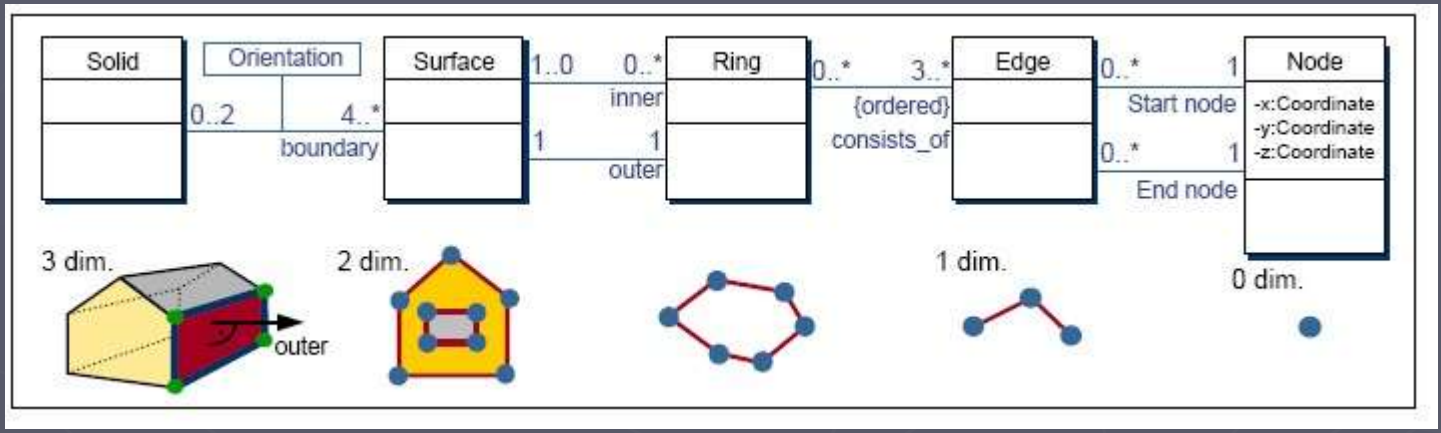


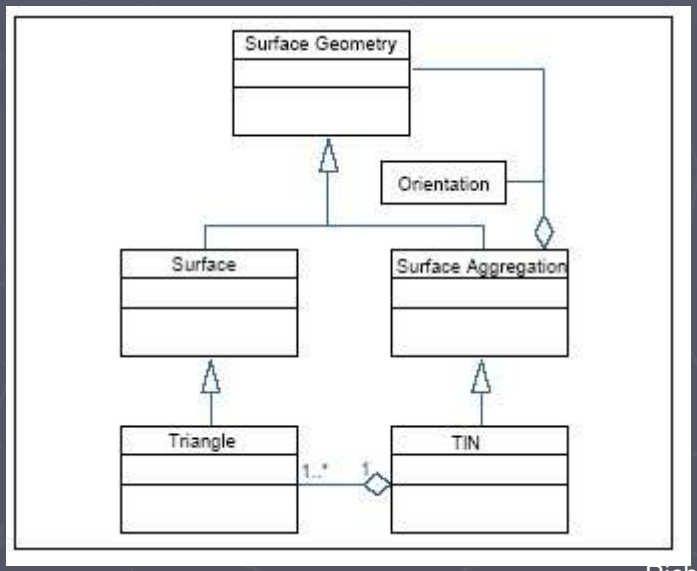
Hamilton et al.

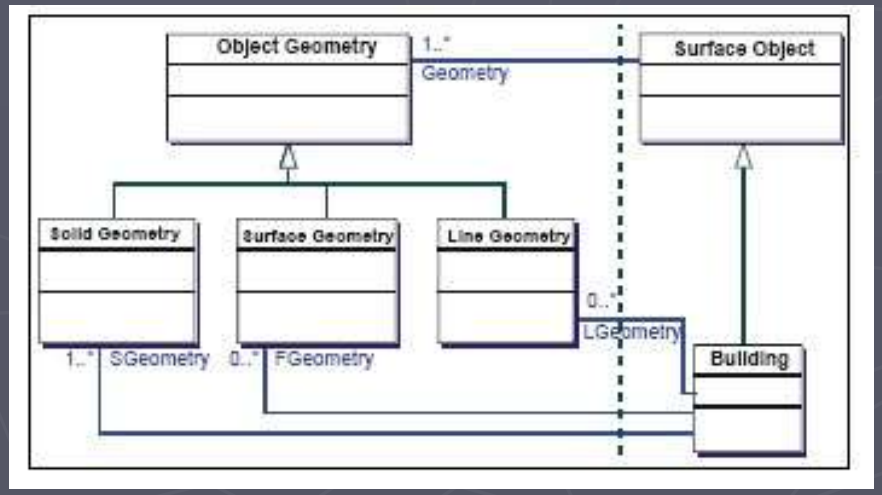
- Conceptual urban data model
- Emphasis on interoperability


Railway
(from RailwayPackage)
railwayID : Integer
railwayName : String
descriptiveTerm : String
startNode : Point
endNode : Point
length : Float
polyline : Polyline
WaterElement
(from WaterPackage)
waterElementID : Integer
typeOfWaterElement : String
descriptiveTerm : String
boundary : Polyline
HeritageElement
(from HeritagePackage)
heritageElementID : Integer
name : String
point : Point
boundary : Polyline
Pollution
(from PalutionPackage)
pollutionType : String
UrbanFurniture
(from UrbanFurniturePackage)
urbanFurnitureID : Integer
point : Point
TerrainHeightObject
(from TerrainHeightPackage)
terrainHeightObjectID : Integer
point : Point
boundary : Polyline
StructureElement
(from StructurePackage)
StructureElementID : Integer
name : String
descriptiveTerm : String
point : Point
boundary : Polyline
AdministrativeBoundary
uniqueID : Integer
type : String
outline : Polyline
contains : String
MetorologicalConditions
(from MetorologicalConditionsPackage)
metorologicalConditionsID : Integer
windVelocity : Float
windDirection : Float
season : String
dayOrNight : Boolean
dayNightHours : Integer
cloudiness : Integer
Road
(from RoadPackage)
roadID : Integer
roadName : String
descriptiveTerm : String
LandElement
(from LandPackage)
landElementID : Integer
name : String
outline : String
Country
UserDefined
County
UrbanFragment
CrimeIncident
(from CrimePackage)
crimeIncidentID : Integer
type : String
location : Integer
featureID : String
City
District
IFCBuilding
(from BuildingPackage)
globalID : String
name : String
buildingAddress : String
xTOID : String
xOutline : Polyline
xHeight : Float
xLocation : Integer
xOrientation : Integer
xParcelID : String
xSize : Real
Parcel
ParcelComplex
PartitionParcel
1
0..*
*
0..1

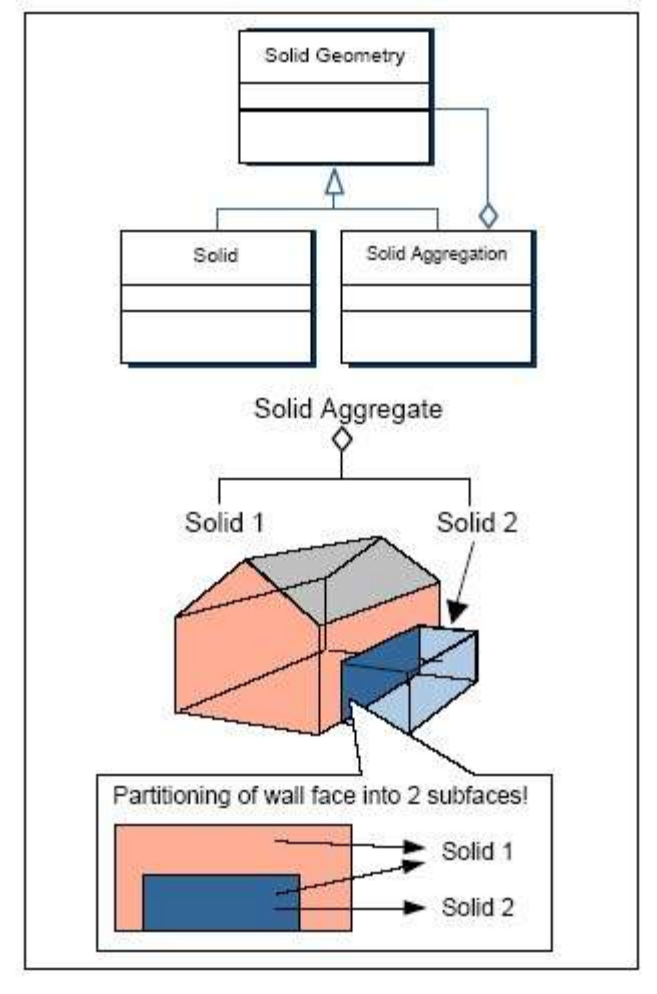
Kolbe, Groeger – City GML

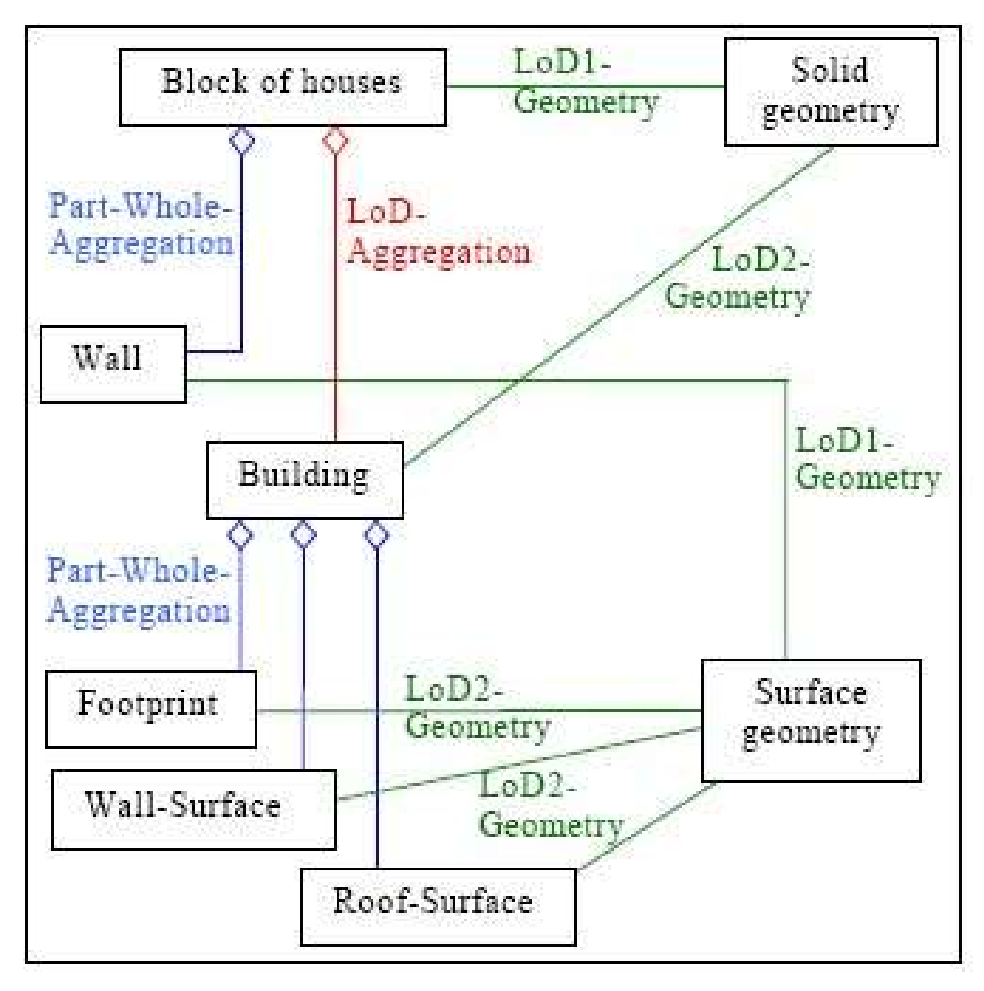




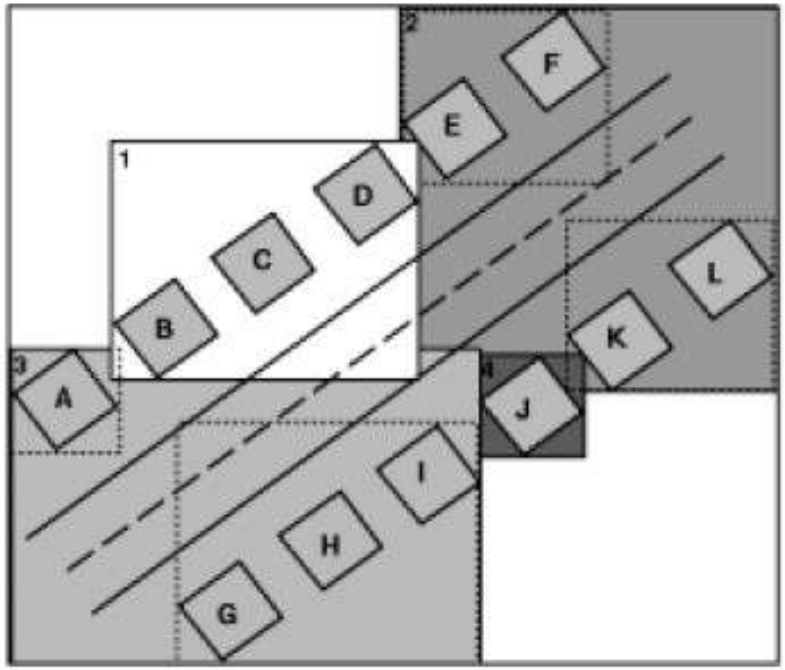


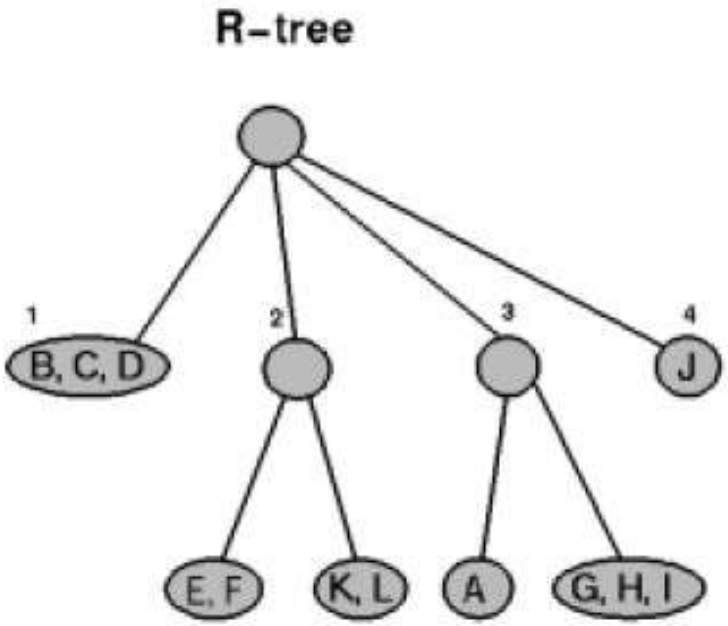
Kolbe, Groeger – City GML





Kofler, Guber – LOD-R-tree





An object-oriented approach

- structural object orientation - any entity, independent of whatever complexity and structure, may be represented by exactly one object
- operational object orientation – operations on complex objects are possible without having to decompose the objects into a number of simple objects
- behavioural object orientation – a system must allow its objects to be accessed and modified only through a set of operations specific to an object type

- four main concepts
  - encapsulation, inheritance, object identity, polymorphism

3D GIS data management

- Weaknesses of the RDBMS
  - poor representation of "Real World" entities
  - semantic overloading
  - poor support for integrity
  - homogenous data structure
  - limited operations
  - difficulty handling recursive queries
  - impedance mismatch
  - other problems
- Experts agree that it is necessary to move to the next generation of DBMS – object servers

3D GIS data management 2

- Strengths of the OODBMS
  - enriched modelling capabilities
  - extensibility
  - removal of impedance mismatch
  - more expressive query language
  - support for schema evolution
  - support for long duration transactions
  - applicability to advanced database applications
  - improved performance
- OODBMS offer the way to evolve the GIS

Conclusion

- Development of a new 3D GIS should cover
  - Object-oriented approaches
  - Object-oriented development
  - Object-oriented data modelling
  - Object-oriented language
  - Object-oriented data store

Examples

- CyberCity AG
- Geonova AG
- Planet 9 studios
- GeoSim systems
- Urban Simulation Team at UCLA

Discussion

- Your questions
- Your opinions
- Your recommendations

Thanks for Your patience

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